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REPORT OF THE BARBERRY AND THE BLACK RUST OF WHEAT SURVEY IN SOUTH WEST WALES.

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DURING the past two years several cases of the disease known as "black rust" of wheat, caused by the fungus *Puccinia graminis*, have been reported from South West Wales, and in view of the serious nature of this disease the Ministry of Agriculture and Fisheries, in conjunction with the Department of Agriculture of the University College of Wales, Aberystwyth, instituted investigations, the results of which are embodied in this report.

It is well authenticated that the common barberry (*Berberis vulgaris*) serves as spring host for the fungus which causes the black rust disease, and with the object of ascertaining the distribution of the common barberry and the extent of the occurrence of black rust a survey of the counties of Carmarthen, Cardigan and Pembroke was undertaken in the summer of 1920. Owing, however, to the many difficulties involved it has not yet been possible to complete the work.

Methods employed in the Survey:—

Visits to Farms.—As many farms as possible within a selected area were visited. The growing wheat and any straw lying about were carefully examined, and where evidence of disease was found search was made for barberry bushes. This method gave good results but took considerable time.

Interviews.—Few young or middle-aged persons appeared to know anything about the barberry bush, but it seemed to be familiar to the older people, especially women. Good and reliable information was readily furnished by elderly people in remote country districts. The help of schoolmasters in the rural districts was solicited, and in each case valuable assistance and information were obtained.

Exhibitions of Specimens.—Specimens of the common barberry and the black rust of wheat have been exhibited, particularly at the United Counties Agricultural Show, Carmarthen, in July, 1920. By this means interest was aroused amongst farmers which resulted in the location of a number of barberry bushes.

Personal Search.—Personal search, independent of outside help, was also made. The growth, colour and form of the barberry are characteristic, so that while travelling along country

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roads it was possible, after a little experience, by glancing round the hedgerows to " spot " bushes growing in the vicinity. This method also yielded good results.

The survey extended over a period of three and a half months (May-August, 1920), but, when the hilly nature of the country and the difficulty of travel are considered, it will be readily understood that in this short period it was not possible to investigate more than one-third of the entire area.

Description of the Bush.—The common barberry (*Berberis vulgaris*), known in Welsh as *pren melyn*, or *pren clefyd melyn*, is said to be a native of Asia. It was introduced into Europe during the fifteenth century and cultivated as a " fruit " bush for several hundred years, until it was found to spread the rust " seeds." The berries were used in the preparation of preserves and jellies, and their juice for making wine and vinegar. When allowed to grow wild it is a tall erect shrub, often as many as 10 or 12 ft. high, and it is a persistent grower. The branches " are arched and hanging at the ends." The bark is greyish in colour and the wood is yellow. The branches bear three-parted spines at the base of the tufts of leaves (Fig. A). The leaves on the young shoots are alternate and green or purple in colour, but on the old shoots they occur in clusters. They are egg-shaped, rather stiff, and have saw-tooth edges (Fig. C). The berries are small, red, oval, and contain one or two seeds (Fig. B). The bark has been largely used for making a concoction which, the old people say, is an infallible cure for yellow jaundice (*clefyd melyn*) and for various diseases of cattle. It is not now, however, included in the British Pharmacopœia and is not used by dispensing chemists as it is not proved of value in these diseases, and its place as a bitter tonic has been taken by a number of drugs, such as gentian, quassia, dandelion or quinine.

Occurrence of Barberry.—Although the survey is incomplete, enough has been done to show that the bush is widely distributed in the three counties. In Carmarthenshire, 100 farms were visited and barberry was found to exist on 60 of them. It occurred chiefly round the homesteads and in the hedges about the farms. In all there were discovered 55 single bushes and 144 yd. of barberry hedge, the latter occurring in strips from 6 to 40 yd. in length. Each strip of barberry hedge, or even a single bush, may be the centre of a local outbreak of the disease, and 64 of these possible centres extending over 24 parishes, were located in this county. In South Cardiganshire, 40 farms were visited and barberry was seen on 30 of them. In all there

were found 25 bushes, and 68 yd. of barberry hedge—30 possible centres of infection, extending over 12 parishes. Pembrokeshire has not been systematically worked, but barberry is known to exist in 14 parishes. At one place there is a stretch of barberry hedge over 100 yd. long, and at another about 70 yd. long. These were the largest stretches met with, and it is a long time since wheat was grown near them. It is clear that if the survey were continued a very great deal more barberry would be discovered.

Extent of Black Rust on Wheat.—Time would not allow of justice being done to this part of the work, and in many places where barberry was found it was impossible to examine the wheat growing in the neighbourhood. However, 45 cases were observed in Carmarthenshire, 15 in South Cardiganshire and 14 in Pembrokeshire. In each of these cases, moreover, barberry was found in the immediate vicinity. From conversations with farmers there can be no doubt that the disease has long been prevalent over the greater part of the three counties.

Results of Personal Interviews.—It has been said that the farmers of a generation ago were aware that the common barberry caused the black rust of wheat. This, however, cannot be said of the present-day farmer in the surveyed district. To him the life-cycle of the fungus is a mystery and the disease is known to most of the farmers under the name of "blast"* and is regarded, as are most other diseases, as entirely due to wet weather. This idea is very deep rooted, and the fact that the life-history of *Puccinia graminis* seemed to many like a fairy tale, made it very difficult to convince them as to the true nature of the disease. Consequently, the way in which the information and advice given was received by the farmers depended chiefly upon the educational attainments of each individual, the quantity and position of the barberry and the condition of the wheat. Very few farmers, who had the black rust affecting their wheat, acted upon the advice given and removed the barberry at once, but every farmer who had barberry on his land admitted that he could never obtain a good crop of wheat when it was grown near the bush. The popular variety of wheat is "Hen Gymro" (Old Welshman) which is particularly susceptible to the black rust.

* Local terminology in respect to plant diseases is very indefinite and confused. "Blast" is applied to all rust diseases of cereals; "blight" and "blast" to the *Phytophthora* disease of potatoes and "blight" to Woolly Aphis on apple trees. The term "duon" (blacks) is also used in South Wales to designate black diseases of cereals such as rust, but more especially smut, while in North Wales bunt and smut are both known as *penddu* (blackhead).

Field Observations on the Disease.—

Spring Stage.—The disease appears on the under surface of the leaves of the common barberry in the form of yellow or orange-coloured swollen patches (Fig. A). These patches vary in size and may be as much as half an inch in diameter, and when examined by the aid of a hand lens are seen to consist of numerous cups known as "cluster cups." During the year 1920 the cluster cups were first observed on the barberry in Pembrokeshire on the 8th May, and from that date they were seen continuously until the end of August. On reaching maturity a few weeks after the appearance of the spot the cluster cups open and the contents (a very fine yellow powder) are easily distributed by the wind. This powder consists of the spores* or "seeds" of the fungus, which when blown on to wheat produce, if conditions are favourable, the summer or "red" rust stage.

Summer Stage.—The summer stage generally appears on the wheat leaves and stems in the form of reddish-brown, elongated spots, which give the wheat a rusty appearance. From its abundance on the stems the disease is termed in America the black *stem*-rust. These spots consist of masses of "summer spores"† which help to spread the disease during summer. The first outbreak of the disease for the year 1920 was noted on the 27th July on autumn sown wheat in Pembrokeshire. The second case was found in Cardiganshire on the 28th July; it was a bad attack, and apparently the disease had commenced much earlier than the date of the visit. This view was confirmed by the farmer, who stated that he had noticed the disease about the first or second week in July. The summer-spore stage was also seen on spring wheat "April Bearded" as late as the 13th September. The time of appearance of the disease in all probability depends on (1) climatic conditions, (2) proximity of barberry, and (3) state of maturity of the wheat.

The Winter or Black Stage.—A winter stage gradually displaces the red summer stage. It appears on the surface of the stem in the form of conspicuous black streaks, which consist of the resting spores‡ of the fungus (Fig. D). During the year 1920 this stage was observed as early as the 27th July, the same date as the red stage, and it was here noted that the transition from the red summer stage to the black stage had taken place comparatively quickly, probably within a fortnight's time. In other

* The spores from the cluster cups or *aecidia* on barberry are called aecidiospores.

† The Summer spores on the wheat are termed uredospores.

‡ The resting spores produced from the black stage on the wheat are termed teleutospores.

THE COMMON BARBERRY (*Berberis vulgaris*).

A.—Flowering Shoot in May or June, showing the Cluster Cup stage of the Rust Fungus forming yellow or orange coloured spots on the leaves. The spines on the stems, usually in threes, distinguish this from most common, garden Barberries.

B.—A Shoot in Autumn, with long red Berries which hang in clusters.

C.—Leaves, enlarged, showing tooth margins and the yellow spots with the Cluster Cup stage of the Fungus. The spores from these cups infect the Wheat.

D.—A small piece of Wheat attacked by Black Rust showing as black lines on the stem.

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cases (see below) the change took place more gradually. The black resting spores remain dormant on the straw and stubble through the winter, germinate in the spring and give rise to other minute spores, which infect the barberry leaves, thus completing the life-cycle of the fungus.

A small point, though possibly of great practical importance, was observed in connection with the summer spores. It was noted that in some varieties of wheat these spores (the uredospores) did not break through the epidermis of the stem. The red stage was visible within the stem but it never burst through, merely slowly changing to the black or teleutospore stage. Late in the season, when the transition from one stage to the other was complete, the epidermis was ruptured and the black winter-spores were exposed for dispersal. This might have been an unusual occurrence due to the low temperature prevailing through the summer. However, the matter calls for further investigation, because, if varieties of wheat can be found in which the uredospores are not exposed for dispersal, such varieties will not spread the summer stage. Further, the rupturing of the epidermis injures the wheat owing to the loss of water by evaporation, and if this does not take place in some varieties until late in the season these should give better yields than those in which the epidermis is broken early. In short, varieties of wheat in which the uredospore stage does not break through, the epidermis may be regarded as partial "resisters."

Spread of Disease from Barberry to Wheat.—The spread of the disease from barberry to wheat was observed fairly closely at two places. In one case, there were two barberry bushes in the middle of a hedge alongside the wheat, and in the other there was a strip of barberry hedge, eight yards long, near one corner of the wheat field. In both cases it was obvious that the disease had commenced, and that the intensity was greater, near the barberry. To one of these places two farmers were taken to witness this for themselves, and after going carefully over the field they were fully satisfied that the barberry was a contributing factor in disseminating the disease.

Effect of Black Rust on Wheat Growing in South West Wales.—Although this part of Wales is mountainous and not considered generally suitable for wheat growing, there are districts where wheat might be more successfully grown if it were not for the presence of the barberry and the black rust disease. Most of the farmers endeavour to grow enough for home consumption, and many would sow more wheat if they

could grow a profitable crop. The conditions are clearly least favourable within "Barberry Areas." Some of the farmers have tried wheat-growing so often, with such disappointing results, that they have given up the practice altogether. In face of this evidence, one is forced to the conclusion that the barberry is directly responsible not only for a considerable reduction in yield per acre but also in the amount of wheat grown, and that if this factor were eliminated the yield and acreage would appreciably increase.

It may further be noted that in 1920 the Ministry of Agriculture made a special effort to ascertain all cases of black rust in the country. England as a whole was found to be remarkably free from the disease, and the common barberry is scarce. A few quite small outbreaks were located, the worst case, in Gloucestershire, being in immediate proximity to badly rusted barberry in a hedge. Many farms in parts of Devonshire and Cornwall (which counties have a similar climate to South West Wales) were examined and no case of black rust was observed, and during the inspection hardly a single bush of the common barberry was met with.

Losses caused by Black Rust.—In order to give some idea of the damage caused by this disease, the losses suffered by a farmer in Cardiganshire during the last two years might be quoted. On this particular farm there was, until recently, a strip of barberry hedge ten yards long. In 1919 wheat was grown alongside this hedge and the intensity of the disease was so great that the crop only yielded eight bushels per acre, and the straw was of little value. During 1920 wheat was again grown near the barberry, but on advice the latter was cut down on the 20th May. This date was, unfortunately, rather too late, as cluster cups were present on the barberry and some of the spring spores had already been dispersed. The disease made its appearance in July. Before the crop was cut it was noticed that the intensity of the disease was much less than in 1919, and on being threshed the crop yielded sixteen bushels per acre, and the straw was much better. This decrease in the severity of the attack might have been partly due to the cold, wet summer, but there is reason to believe that the cutting down of the barberry also helped. In any case, the farmer was quite pleased with the result, and will dig up the entire plants with roots before next spring. From this example it will be seen that the losses caused by the disease may be very high, and in years of epidemics the crop

may be practically a total loss. The statistics for the year 1919 give the area under wheat in the counties of Carmarthen, Cardigan and Pembroke as 22,000 acres, and much of this wheat land must fall within the range of influence of the barberry, so that the loss directly attributable to the latter is in the aggregate very considerable, even assuming that the existence of the barberry is not, as many now believe, an absolutely essential condition for the existence of the disease on wheat.

Summary.

1. It is ascertained by means of the survey that the common barberry is widely and plentifully distributed in Carmarthenshire, Pembrokeshire and South Cardiganshire. The cluster-cup stage of the black rust fungus is abundant on the barberry in spring and early summer.

2. On the wheat black rust may be said to be generally distributed over the same area, and causes serious losses every year. In certain seasons the attacks are very severe.

3. Wheat is regarded as a risky crop in these counties, and is certainly not a paying one in barberry areas. As a result there is a reduced acreage under wheat, and this is diminishing.

4. The common barberry is the alternate host of black rust, giving the fungus a good start each spring. In several concrete cases field-observations showed that the disease was most intense near the bushes and had started from them. As long as barberry is allowed to remain it will be a constant source of infection, not only to the adjacent wheat fields, but to other fields on which the summer spores from the wheat will be blown.

5. In more than one case, the removal of barberry bushes resulted in slighter attacks on adjoining fields than in the previous season, but until barberries are eradicated on a wholesale scale no complete elimination of the disease can be expected, owing to spores blowing from other fields. Every bush destroyed means so many less initial infections and the fewer the infections the better will be the wheat crop.

6. Black rust is very scarce in all other parts of the British Isles and there appears no reason to doubt that if the barberry were exterminated in Wales the annual attack of black rust on wheat would subside. This method was adopted in Denmark eighteen years ago, and black rust in that country has now practically ceased to exist.

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POLLINATION OF FRUITS.

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IN choosing land for fruit planting, there are several factors to be considered, such as distance from market, climate, aspect, and protection from frost by careful selection of site. The next point is the kind of fruit to be planted, after which comes the choice of varieties suitable for the district. The prospective planter is advised to limit the number of varieties he plants to, say, six varieties of each kind of fruit tree grown, in order to be able to send considerable quantities of each variety to market.

Growers have sometimes planted a single variety alone by the acre (for example, Lane's Prince Albert Apple, Pitmaston Duchess Pear, River's Early Prolific Plum, or Early River's Cherry), with the result that, although it has grown strongly and flowered profusely, it does not fruit satisfactorily. The reason for this is that, in Nature, each apple, pear, plum or cherry tree springs from a separate seed; each tree is a distinct individual. The nurseryman or fruit grower compares the fruit of the different trees and selects those which produce the best fruit. Experience has taught him that the majority of trees grown from seed are not quite like their parents: in most cases their fruits are inferior to those of the parent. He therefore takes shoots of the selected tree and propagates the variety by grafting or budding on suitable stocks. Now each of these trees is part of the original tree: each bears similar fruit and has similar habits.

Nature in general favours cross-pollination for the production of good-sized fruit and seed of vigorous growth, but in the case under consideration each tree is similar, being of the same origin and not grown fresh from seed according to Nature's plan. Pollination by the same variety is, therefore, a form of self-pollination, and does not give the best result in the majority of cases.

Practical botanists in England, America and Australia, who have made experiments on the fruiting of the apple, pear, plum and cherry, find that relatively few varieties are strongly self-fruitful. Of apples, less than one-half of the varieties appear to be self-fruitful; of pears, about one-half; of plums, about